

NOTES ON ASTEROIDS IN THE BRITISH MUSEUM
(NATURAL HISTORY)—I

The Species of *ASTROPECTEN*.

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(With four plates.)

THE large and valuable collection of Asteroids in the British Museum (Natural History) is being revised. This paper, describing what has seemed worthy of description concerning the collection of *Astropecten*, will, it is hoped, be the first of a series. It is therefore numbered as such.

The following species of *Astropecten* are represented in the Museum collection ; those of which the types are held are marked with an asterisk (*) :

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| * <i>acanthifera</i> Sladen | <i>kagoshimensis</i> de Loriol |
| <i>andersoni</i> Sladen | <i>mammilatus</i> Koehler |
| <i>antares</i> Döderlein | <i>marginatus</i> Gray |
| <i>antillensis</i> Lütken | * <i>mauritanus</i> Gray |
| <i>aranciacus</i> Linn. | * <i>mesactus</i> Sladen |
| * <i>armatus</i> Gray | <i>michaelseni</i> Koehler |
| <i>articulatus</i> (Say) | <i>mindanensis</i> Döderlein |
| <i>bispinosus</i> Otto | * <i>monacanthus</i> Sladen |
| <i>brasiliensis</i> M. and Tr. | * <i>pectinatus</i> Sladen |
| * <i>brevispinus</i> Sladen | <i>platyacanthus</i> Philippi |
| <i>duplicatus</i> Gray | <i>polyacanthus</i> M. and Tr. |
| * <i>formosus</i> Sladen | <i>preissii</i> M. and Tr. |
| <i>granulatus</i> M. and Tr. | <i>pusillulus</i> Fisher |
| <i>granulatus natalensis</i> n. subsp. | <i>regalis</i> Gray |
| <i>griegi</i> Koehler | <i>sanctae helenae</i> Mortensen |
| <i>hartmeyeri</i> Döderlein | <i>scoparius</i> M. and Tr. |
| <i>hemprichi</i> M. and Tr. | * <i>sphenoplax</i> Bell |
| * <i>hermatophilus</i> Sladen | <i>spinulosus</i> Philippi |
| * <i>imbellis</i> Sladen | <i>triseriatus</i> M. and Tr. |
| <i>indicus</i> Döderlein | * <i>triseriatus fijiensis</i> n. subsp. |
| <i>irregularis</i> (Pennant) | <i>vappa</i> M. and Tr. |
| * <i>irregularis pontoporaicus</i> Sladen | <i>variegatus</i> Mortensen |
| <i>javanicus</i> Lütken | <i>velitaris</i> von Martens |
| <i>johnstoni</i> (Delle Chiaje) | <i>vervilli californicus</i> Fisher |
| | * <i>zebra</i> Sladen |

Something is written below of fifteen of these forty-nine species. Five (*granulatus*, *indicus*, *monacanthus* and *zebra* and *hartmeyeri*) are discussed chiefly because the Museum specimens show that, within each, the range of variation is greater than had previously been described. In one of them (*granulatus*) variation is correlated with locality and a new subspecies is created. In four other species (*brevispinus*, *mesactus*, *pectinatus* and *sphenoplax*) re-examination has shown the presence of many more actinal intermediate plates than was hitherto known ; they extend much farther down the arm than is normal in the genus. The Museum specimens of *triseriatus* have made possible a fuller description of that little-known form ; one of them is described as a new subspecies. *A. michaelseni* Koehler is shown to include *A. dahomensis* Döderlein ; some notes on the Museum specimens are added. Some Museum specimens of *A. antillensis* appear to show that the species has a greater range than was previously known.

Before the war a search was made for Gray's Asteroid types. Of those of his species of *Astropecten* which, according to Döderlein (1917), are still valid as species

or subspecies, the types of only three were found. They are those of *A. brasiliensis armatus*, *A. brasiliensis erinaceus* and *A. mauritianus*. They are redescribed and figured.

Astropecten granulatus Müller and Troschel

(Plate I, figs. 1 and 2.)

Astropecten granulatus Müller and Troschel, 1842, *Syst. Ast.* : 78 ; Sladen, 1889 : 215, pl. 35, figs. 3-4, pl. 39, figs. 4-6 ; Koehler, 1910 : 266 ; Döderlein, 1896 : 305, pl. 18, figs. 30 and 30a ; Döderlein, 1917 : 148, pl. 5, fig. 7 ; pl. 14, figs. 1, 3 and 3a ; pl. 17, figs. 2, 2a and b ; Fisher, 1919 : 73 ; Clark, H. L., 1923 : 250 ; Livingstone, 1932 : 242, pl. 8, figs. 2 and 3 ; Clark, H. L., 1938 : 60, pl. 1, fig. 1 (in colour).

The locality from which the types of this species came is not known, but all subsequent records, with the exception of that of Clark (1923), have been from Australian, E. Indian or Philippine seas. Clark recorded it from off the coast of Natal and from off Cape Agulhas (one "young and dubious specimen"), in South African waters. But in 1938 he changed his opinion, saying : " Comparison of the South African specimens (those he described in 1923) with the material from Broome indicates that it is quite different and further study suggests that it is nearer to *A. notograptus* Sladen than to any species hitherto described. Hence *granulatus* should be deleted from the list of South African sea-stars."

There are in the British Museum (Natural History) fourteen South African specimens which I am satisfied are of the same species as those Clark ascribed to *A. granulatus*. They were presented in 1904 by the Cape of Good Hope Government under the following reference numbers :

Ref. No. 49—1 specimen	Ref. No. 10639—6 specimens
101—1 ,,	10723—2 ,,
? 171—3 specimens	10894—1 specimen

A search of the correspondence between the Marine Biologist at the Cape (Dr. Gilchrist) and Professor Jeffrey Bell concerning the Echinoderms sent to the British Museum from the Cape between 1897 and 1904 shows that each specimen had a reference number and that lists, giving localities against reference numbers, accompanied Dr. Gilchrist's letters. Some of the lists have been found, but not any including one of the reference numbers above. One of them, however, is to be found in Bell's paper on the Asteroidea (1905, p. 244). It is 10639 and the accompanying data read : "Cape Natal W. by N. 4½ miles, large dredge, 47 fms., sand and shells." Professor Bell named these specimens *Astropecten pontoporeus*. It must, unfortunately, remain unknown exactly where the other specimens came from.

There are twelve specimens from Australian waters: the "Challenger" specimen ; the Barrier Reef Expedition specimen figured by Livingstone ; two specimens from Broome received through Dr. H. L. Clark from the Museum of Comparative Zoölogy ; one from 36 fathoms on the north side of Holothuria Bank and four from Roebuck Bay (Admiralty) ; and three specimens from "West Australia" (Australian Museum, Sydney).

A comparison of the two sets of specimens, the Australian augmented by ample description and illustration in published papers, does not convince me that they are of two species :—

	R : r in mm.	Br in mm.	No. of superomarginal plates
<i>South African Specimens</i>			
Reference Number 10639	13 : 4=3·2	3	13
171	16 : 5=3·1	3·5	16
10639	19 : 6=3·1	5	16
101	20 : 6=3·3	5	17
10639	22 : 7=3·1	6	15
10894	23 : 7=3·3	5·75	18
171	26 : 7=3·7	5	18
10639	30 : 9=3·3	7	17
10639	32 : 10=3·2	9	20
49	35 : 8=4·4	7	22
10723	35 : 9=3·9	8	18
10723	37 : 11=3·4	8·5	19
171	39 : 11=3·5	8	20
<i>Australian etc. Specimens (including those described in the literature)</i>			
W. Australia (Clark, 1938)	7 : 3=2·3	3·5	10
Philippine Is. (Fisher, 1919)	15 : 5=3		
Aru Is. (Koehler, 1910)	21 : 6=3·5		19
Arafura Sea, "Challenger" [in British Mus. (Nat. Hist.)]	21 : 7=3	4	18
Holothuria Bank [in B.M. (N.H.)]	22 : 6=3·7		22
Thursday Is. (Döderlein, 1896)	29 : 8=3·6		24
Broome, W. Australia [in B.M. (N.H.)]	35 : 10=3·5	6·5	29
Barrier Reef (Livingstone, 1932)	38 : 10=3·8	5·5	29
West Australia [in B.M. (N.H.)]	44 : 11=4		26
West Australia [in B.M. (N.H.)]	46 : 11=4·2		27
Western Australia [in B.M. (N.H.)]	46 : 13=3·5		27
Roebuck Bay [in B.M. (N.H.)]	77 : 18=4·3		40
West Australia (Döderlein, 1917)	79 : 17=4·7		42
Roebuck Bay [in B.M. (N.H.)]	83 : 15=5·5		41
Broome [in B.M. (N.H.)]	86 : 15=5·75	14	39
Roebuck Bay [in B.M. (N.H.)]	88 : 16=5		42
Roebuck Bay [in B.M. (N.H.)]	93 : 19=4·9		41
West Australia (Clark, 1938)	118 : 22=5·4		45

Note.—One of the S. African specimens (Ref. No. 10639) is too distorted to measure.

There are differences, some of which are brought out in the table. The number of superomarginal plates is greater in Australian than South African specimens : of two specimens of $R=35$ mm. the South African has twenty-two, the Australian twenty-nine ; a South African specimen of $R=37$ mm. has nineteen marginal plates, while an Australian specimen of $R=38$ mm. has twenty-nine. The covering of the superomarginal plates of the South African specimens is a little less dense, that of the inferomarginal plates a little more dense, than those of Australian specimens, but they are of the same nature ; and the difference in the inferomarginal plate covering is not greater than that between Aru Islands and Thursday Island specimens shown in Döderlein's figs. 2a and 3 (1917, pl. 17). The second of the two marginal spines of the inferomarginal plates is in most, but not in all, South African specimens bigger in proportion to the first than it is in Australian specimens, being often two-thirds and sometimes three-quarters as long.

The only difference that I see in the general facies is that of the relative proportions of the inferomarginal spines ; that the superomarginal plates of Australian specimens encroach more on the abactinal surface than do those of South African specimens ; and that two of the South African specimens have spines on some of the superomarginal plates. One of them is remarkable in having large spines, more than 2 mm. long, on the first superomarginal plates in some

interradii but not in others. The spines on the more distal plates of both specimens are smaller, about half the length of the plates on which they occur. They are broad based and pointed—*i.e.*, sharply conical.

Clark (1923, p. 251) wrote: "One of the smaller African specimens shows six superomarginal spines," but he does not state where they occurred. Their very irregular occurrence in the two British Museum specimens is shown in the following table :—

Specimen	Rays—showing number of individual superomarginal plates on either side on which spines occurred.									
	1		2		3		4		5	
	a	b	a	b	a	b	a	b	a	b
Ref. No. 49, R=35 mm.	1		1				1 1		1 ?1	
			9 9		7 7		7 7		8 8	
			10 10		8 9		8 8		10 ?9	
			12 11		9 10		9 9		?10	
					10 11		10 11		?11	
Ref. No. 10723, R=37 mm.	10 11		9		10 6		6		8	
					12 7		7		9	
					13 11					
					14 12					
					15 13					
					14					
							Rays broken off at 10th superomarginal plates			

Many characters are shared in common by the two sets of specimens. The paxillae, with all their variations of age, are essentially the same. A characteristic feature is the raised rim which the outer spinelets form around the shorter central granules and the unequal size of the latter (Döderlein's fig. 2a, pl. 17, 1917, shows this very well.) The rim is least apparent in the very large Australian specimen (R=86 mm.) in which all the spines are of roughly equal length and have flattened polygonal ends; but it tends to be present even there. The number of spines or granules present on the largest paxillae varies from one or two central and seven to ten peripheral in the smallest specimens, to ten to seventeen central and fifteen to seventeen peripheral in those of medium size. In the largest specimen (R=93 mm.) there are twenty-five to thirty in the centre and about twenty-five around the edge. The shape of the larger paxillae where they are crowded tends to be polygonal.

The characteristic spines which occur among the squamules on the ventral surfaces of the inferomarginal plates are present in nearly all the British Museum specimens, Australian and South African alike. They are flattened and blade-like with an irregular outline, but each tapers to a point. Their occurrence is very irregular. In smaller, and sometimes in medium-sized, specimens they are present on the first plate only and lie in a row down its centre. In larger specimens they occur too on neighbouring plates, but have moved to the aboral edge; and in very large specimens they may extend to the end of the ray (Döderlein, 1917, pl. 14, fig. 1).

The order of the adambulacral spines is the same in both sets of specimens, but the aboral spine of the second row is much less enlarged in South African than in Australian specimens; it is only slightly bigger than the adoral.

More South African specimens are required before it can be said whether the form occurring there is best called a separate species. In the meantime it seems

wise to regard it as a new sub-species—subsp. *natalensis*, distinguished by its smaller number of superomarginal plates, which may carry spines, and by other differences, detailed above (in the covering of the marginal plates, the relative proportions of the two spines of the inferomarginal plates, etc.), which are of degree and not of kind; and, even so, are not constant.

The Australian specimen of $R=46$ mm. which has the unexpectedly large minor radius of 13 mm. has unusual numbers of actinal intermediate plates. In two interradia there are five; in the other three there are six, seven and nine respectively. The nine are arranged as a chevron of seven enclosing a pair in its angle.

Astropecten indicus Döderlein.

Astropecten indicus Döderlein, 1888, *Zool. Jb. Abt. 1*: 828, pl. 31, figs. 2a-d; Koehler, 1910: 27, pl. 4, figs. 8-15; Döderlein, 1917: 146, pl. 14, figs. 4-4a.

Astropecten koehleri Loriol, 1899, *Mém. Soc. Phys. Genève*: 19, pl. 1, fig. 5; Döderlein, 1917: 122, pl. 11, figs. 1-1a.

Astropecten pleiacanthus Bedford, 1900, *Proc. Zool. Soc. Lond.*: 292, pl. 24, figs. 9a-c.

There are in the collection ten specimens which appear to me to show that Koehler (1910) was right in uniting *A. koehleri* with *A. indicus*, a conclusion with which Döderlein (1917) did not agree. He thought *koehleri* to be sharply marked off from *indicus* by (a) the possession of well-developed spines on the inner margins of the more proximal superomarginals, and (b) the presence of well-developed rows of spines along the distal edges of the inferomarginals. How he can have held the first, (a), after Koehler's careful description of a series I do not know. The second, (b), I find a more puzzling point.

The ten specimens are as follows:—

No.	R : r in mm.	No. of superomarginals	Locality	Source	Remarks
1	9 : 3=3	15	Ceylon	Herdman collection	Does not have characters of adult, but presumed because of its occurrence with one to belong to this species.
2	24 : 8=3	17	India—probably near Madras	Day collection	
3	24 : 8.5=2.8	19			
4	35 : 8=4.4	25	N. coast Socotra	H.M.S. "Weston"	Paratype of <i>A. pleiacanthus</i> , Bedford.
5	28 : 8=3.5	23	Ceylon	Dr. Ondaatje	
6	32 : 9=3.6	24	Singapore	F. D. Bedford	
7	30 : 10.5=3.4	24	Matrah, Iraq	V. H. W. Dowson	
8	37 : 11=3.4	24	Ceylon	Herdman collection	
9	41 : 12=3.4	23	India—probably near Madras	Day collection	
10	42 : 13=3.2	20	Karrachee	J. Murray	

They show, in one direction, an even wider variation in the spination of the superomarginals than did Koehler's series. No. 1, which is very juvenile, has no trace of spines. Nos. 2 and 3 each has a small spine on practically every superomarginal; they are inner spines on the first three plates and pass to the outer edge on the fourth to sixth plate. No. 4 is similar except that on most arms the inner

spine is confined to the first two plates, and the outer series begins on the second plate, which therefore has two spines. No. 5 is a dry specimen which has lost many spines. It seems to have been similar to Nos. 2 and 3. One of its arms is regenerated beyond the fourth superomarginal. The spines borne on the regenerated plates are relatively much bigger than those of the adult arm.

No. 6, the paratype of Bedford's *A. pleiakanthus*, is described below.

No. 7 has large inner spines on the first three to four plates, inner and outer spines on each of the mid-arm plates, single outer spines on the last six or seven plates. No. 8 is rather different, for the spines are very small. There is one to each plate except that on some arms there are one to four unarmed plates between the first three, which have inner spines, and the outer plates, which have spines on the external edge. Some plates at the extremity of the arm are also unarmed.

Nos. 9 and 10 show spination greater than any Koehler described. No. 9 has large single spines on the first three superomarginals. In mid-arm each plate has up to six unequal spines or enlarged granules. They form an irregular row near the distal edge with odd spines or granules standing proximal to it. Four or five plates at the tip of the arm usually have but one, outer, spine. One arm is regenerated beyond the third superomarginal. The regenerated portion bears one spine on each of the twelve plates. No. 10 is similar but even more spiny, for most of the first superomarginals bear two strong spines. For the largest specimen it has a curiously low number of marginal plates (20).

The other characters of these specimens (except for the juvenile No. 1) are those of *indicus* as described by Döderlein (1917).

No. 6 is different and it was long before I decided to treat it as of the same species. (It is the smaller of the two specimens upon which Bedford based his description of *A. pleiakanthus* and it is the one photographed by him.) It has spines on all the superomarginals and they are bigger than those of any of the specimens described above. Two spines occur, very irregularly on different arms, on some of the plates between the third and the eighth; the inner spine of the pair is much smaller than the outer. In this there is no difference in kind from the series described above; but there is such a difference in the armature of the inferomarginals. The first six to nine possess strong spines arising among the scale-like spinelets of the ventral surface. There are three to four on the first, two on the second, and, usually, one thereafter. They lie in the mid-line on the first plate, near the distal edge of the others.

Koehler described these spines as constituting one of the characters of *A. indicus* and shows them in figs. 11 and 12 of his pl. 4. In the other specimens of the Museum series (with the exception of No. 1) there are enlarged spinelets in corresponding positions on the first, second and sometimes on the third to fifth plates; but they are so different in size from those of No. 6 that they are not immediately apparent as its spines are. To regard No. 6 as a separate species because it has these spines would be to suppose that intermediate stages between it and the others of the series do not occur. On the other hand, I cannot assert that they do.

No. 6, however, has another difference. The other specimens of the series (again excepting No. 1) have a rudimentary spine standing proximal to and above the large inferomarginal spine. It is variable in size; in some of the larger specimens it is double. It is not present at all in No. 6.

***Astropecten monacanthus* Sladen.**

Astropecten monacanthus Sladen, 1883, *J. Linn. Soc. (Zool.)*, **17**: 263; 1889: 216, pl. 33, figs. 7 and 8; pl. 37, figs. 10-12; Koehler, 1910: 37, pl. 3, figs. 9-11; pl. 5, fig. 11; Döderlein, 1917: 150, pl. 14, figs. 5-5b; pl. 17, fig. 9; Fisher, 1919: 74; Macan, 1938: 336; H. L. Clark, 1938: 63.

There are in the British Museum twenty-three specimens, including the type, of this species. They come from Arabia, the Maldives, India, the Andamans, Burma, the East Indies and Philippines, and (one large specimen) from Pin Tang in China. Included in this number are seven juvenile specimens ($R=9-15$ mm.) the adambulacral spines of which do not have the characteristic shape of those of the adult. They are regarded as *monacanthus* because they were taken with adults and because most of them have the distinctive disk markings of the species (see below). There are, on the other hand, two juvenile specimens ($R=11$ and 15 mm.) in which the outer adambulacral spines are widened and flattened as in the adult. The largest specimen previously recorded was of $R=53$ mm. (Macan). There are specimens of $R=62$ and 91 mm. in the Museum.

If nothing else were said of this series, this should be recorded: that ten specimens of it have spines or enlarged granules on the superomarginals. Koehler described their occurrence and figured them. But two more recent descriptions of the species have seemed to deny their presence: Döderlein's diagnosis says superomarginals "without spines," although on another page (p. 146) he notes that there may be spines; and Fisher writes of "unarmed granulate superomarginals."

The spines may be very small—no more than enlarged granules; but they may, on the other hand, be anything up to half the length of the plate from which they arise. Their presence is not, so far as this series shows, correlated with size. The largest specimen ($R=91$ mm.) possesses them on some plates near the end of the arms, but they are very small. A specimen of $R=52$ mm. has none. The largest are on a specimen of $R=37$ mm. They occur on four specimens of $R=9-14$ mm., on three of them on the first and second superomarginals only. It may be significant that all the specimens on which they occur come from Indian seas.

Their occurrence is very irregular. They may be only near the end of the arm; or from the fourth or fifth plate to the end; or only on mid-arm plates; or irregularly anywhere; or (in the juvenile specimens referred to above) on the first and second plates only. They are sometimes double.

Fourteen of the specimens, including five of the juveniles, bear characteristic markings on the dorsal side. (All are in spirit.) A dark line lies parallel and near to the margin of the proximal part of each arm on each side, those of contiguous arms being joined around the arm angle to form a chevron. In some of the larger specimens there is also a dusky ring around the centre of the disk from which a band runs down the centre of each arm. The largest specimen has this pattern alone. There may also be dark bands across the arms two-thirds of the way down.

Twelve of the specimens, including some that are fairly large (up to $R=62$ mm.), possess an epiproctal cone.

There is nothing to add to Fisher's account of the adambulacral armature except that in the Pin Tang specimen the adoral spine of the outer series is more broadly spatulate than in any figure, or in any specimen that I have seen.

The largest paxillae of the biggest specimen have up to forty central and thirty peripheral granules. The number of superomarginals of this specimen,

being forty-seven, appears very high. Four specimens of between $R=42$ and 45 mm. have twenty-four to thirty superomarginals; a specimen of $R=62$ mm. has thirty-six.

***Astropecten zebra* Sladen and *Astropecten hartmeyeri* Müller and Troschel.**

- Astropecten zebra* Sladen, 1883, *J. Linn. Soc. (Zool)*, 17 : 261 ; 1889 : 212, pl. 36, figs. 3 and 4 ; pl. 39, figs. 7 and 9 ; Döderlein, 1896 : 306, pl. 18, figs. 31 and 31a ; Lorient, 1899 : 9 ; Bell, 1904 : 149 ; Koehler, 1910 : 44 ; Brown, 1910 : 29 ; Döderlein, 1917 : 155, pl. 14, figs. 8 and 8a ; Clark, H. L., 1921 : 27 ; Livingstone, 1932 : 242 ; Clark, H. L., 1938 : 63.
- Astropecten coppingeri* Bell, 1884, "Alert" Report : 132.
- Astropecten zebra* var. *rosea* Sladen, 1883, *J. Linn. Soc. (Zool.)*, 17 : 263 ; 1889 : 214.
- Astropecten zebra* var. *sibogae* Döderlein, 1917, *Siboga Exped. Monog.* 46a : 156, pl. 6, fig. 4 ; pl. 14, figs. 7 and 7a.
- Astropecten hartmeyeri* Döderlein, 1917, *Siboga Exped. Monog.* 46a : 156, pl. 5, fig. 8 ; pl. 14, figs. 6-6c ; Clark, H. L., 1938 : 62.
- Astropecten hartmeyeri* subsp. *siamensis* Döderlein, 1926, *K. svenska Vetensk.-Akad. Handl.*, (3) 2 : 5, pl. 1, fig. 2.

H. L. Clark (1938, p. 63), in writing of *A. hartmeyeri*, states "whether *hartmeyeri* is really distinct from *zebra* Sladen seems to me rather doubtful, but the only specimens of *zebra* available for comparison are too young to be of real service. Larger collections from North-eastern Australia are necessary for a final decision."

In the British Museum collection there is a series of twenty-four specimens, a description of which may help to solve the problem. They are as follows:—

I. *From North-eastern Australia.*

- A. Torres Strait, Challenger Station 186. Four specimens, the types of *A. zebra*.
- B. Torres Strait, Challenger Station 187. Three specimens, the types of the var. *rosea*.
- C. Thursday Island, Torres Strait, "Alert" Collection. One specimen, the type of *A. coppingeri*.
- D. Torres Strait, "Alert" Collection. Three specimens, labelled *coppingeri*.
- DI. Prince of Wales Channel, Torres Strait, "Alert" Collection. One specimen, labelled *coppingeri*.
- E. Holothuria Bank, Admiralty Collection. Two specimens.
- F. Holothuria Bank, 34 fms., Admiralty Collection. Three specimens.
- G. North-west side of Holothuria Bank, 39 fms., Admiralty Collection. Two specimens.
- H. South of Cape Kimberley, 4 fms., Great Barrier Reef Expedition. Two specimens.

II. *From Western Australia.*

- J. Magnetic Shoal, off Cossack, Admiralty Collection. Two specimens.
- K. Broome. One specimen of *A. hartmeyeri*, presented by Dr. H. L. Clark.

In the following discussion the specimens will sometimes be referred to as of A, B, C, etc. The variation described is tabulated, so far as is convenient, in the table on p. 495.

Döderlein distinguishes *hartmeyeri* from *zebra* by (1) the fact that its superomarginal plates beyond the first three to six nearly always bear small spines on the outer edges, whereas those of *zebra* do not; and (2) the fact that it has

pedicellariae on the first inferomarginal plates in place of the large marginal spine ; small pedicellariae on the lower distal edges of some of the superomarginal plates ; and pedicellariae among the paxillae of the dorsal surface, usually near the marginal plates ; whereas *zebra* has them on the adambulacral and actinal intermediate plates only.

The occurrence of the superomarginal spines and pedicellariae is described as extraordinarily variable.

Discussion of Series.

Superomarginal spines. In the largest of the type specimens (A) the inner spines of the arm angle extend to the sixth plate, becoming progressively smaller. They reach the third plate in the types of the var. *rosea* (B). In one of the largest specimens ($R=23$ mm.) of C and D they extend to the third plate on some rays ; in the smallest ($R=11$ mm.) there are very small spines on the first plates only. In none of these specimens are there spines on the outer edges of the superomarginal plates. It is otherwise with most of the specimens of D1, E, F, G and H. In D1, by far the largest specimen in the series ($R=107$ mm.), there are outer spines on the fourteenth and fifteenth plates on one side of one arm, none on the other side nor on any other arm. In both specimens of E there are spines on all the superomarginal plates except one or two at the ends of the arms ; they move from the inner to the outer edge on the third and fourth plate. In the three specimens of F they extend to respectively, in order of size, the twelfth, seventeenth and sixteenth plates. There are, here and there, gaps in their occurrence : in the smallest specimen they are wanting from the third and fourth plates on most arms. In one of the specimens of G there are inner spines on the first and second, and none on any other plates ; in the second specimen there are small outer spines from the fourth or fifth to the seventh, eighth or ninth plates. H are the specimens listed by Livingstone (1932). One has only large spines on the inner edges of the first and second plates ; the other has, in addition, small outer spines occurring irregularly as far out as the eleventh plate ; some plates, including the first, have two spines.

In the larger specimen of J ($R=46$ mm.) small outer spines extend to the eighteenth superomarginal plate on some rays. They are not always continuous. The change from inner to outer edge takes place on the fourth to seventh plate. In the smaller specimen ($R=12$ mm.) the only spines present are very small ones on the inner edges of the first plates in some interradial spaces. In the large specimen (*A. hartmeyeri*, K) only one or two of the plates of some of the margins are armed with very small outer spines. Examples on different margins are : the ninth and tenth plates, the twelfth and fourteenth plates, the twelfth plate.

Pedicellariae. In the three larger type specimens of *zebra* (A) the first superomarginal plate bears in place of the large marginal spine a small pedicellaria composed of three to six spines ; and in one of them there are eight small pedicellariae on the dorsal surface among the paxillae near the marginal plates. These, undescribed by Sladen, are among the distinguishing features of *hartmeyeri*. In the smallest specimen ($R=11$ mm., Sladen's "young phase") the marginal spine of the first inferomarginal plate is present and there is no pedicellaria. The types of *rosea* (B) resemble those of *zebra* in the occurrence of pedicellariae except that none possesses any in the paxillar field, and the largest has none on the adambulacral plates. In C and D the large spine of the first inferomarginal plate is missing ; it is replaced by a pedicellaria in the larger specimens, but not in the smaller. There

are no pedicellariae among the paxillae. The smallest ($R=11$ mm.) has pedicellariae only on the actinal intermediate plates. In the large specimen D1 there are pedicellariae on the actinal intermediate, adambulacral and first inferomarginal plates; they are also present in small numbers in the paxillar areas near the marginal plates and on the lower distal corners of some superomarginal plates.

In the group of specimens (E, F and G) from the *Holothuria* Bank the first inferomarginal plate carries a spine and not a pedicellaria. Otherwise they vary. The specimens of F have no pedicellariae at all, not even on the actinal intermediate plates. Those of G have the spines of the actinal intermediate plates grouped in a pedicellaria-like way and there are what appear to be incipient pedicellariae on one or two adambulacral plates of one specimen. The specimens of E, which are not very much bigger than those of G and are smaller than some of those of F, are rich in pedicellariae. They are present on the actinal intermediate, and are numerous on the adambulacral, plates. They are also found on the paxillar area: in the smaller there are about ten, all near the marginal plates; in the larger there are over forty grouped for the most part near the marginal plates at the arm angles. The Barrier Reef Expedition specimens (H) have neither large marginal spines nor pedicellariae on the first inferomarginal plates and no pedicellariae in the paxillar area. Both have them on the actinal intermediate plates, but in the bigger only are they present on a very few adambulacral plates.

Turning to the specimens from Western Australia: the large specimen from Cossack (J) has pedicellariae on actinal intermediate and adambulacral plates, in place of spines on the margins of the first inferomarginal plates, and on the dorsal surface (about fifty in number) mostly near the marginal plates; and in addition there are small, low pedicellariae on the lowermost and distal-most corners of some superomarginal plates, more especially those in the proximal part of the arm. The smaller specimen ($R=12$ mm.) has pedicellariae on the actinal intermediate plates and in the arm angles.

The Broome specimen has pedicellariae on the actinal intermediate, adambulacral and first inferomarginal plates as well as many small ones on the dorsal surface near the marginal plates. It has none on the superomarginal plates.

Other Characters. The general facies and the remaining characters of all the specimens are the same. Three sets show a peculiar colour: those Sladen named var. *rosea* are pink; three specimens (F) from the *Holothuria* Bank are a rich straw yellow; the Barrier Reef Expedition specimens are very dark grey. Yet these, as well as the remainder which are the usual museum colour, show the dark pattern characteristic of *zebra*. Döderlein created a variety of *zebra*, var. *sibogae*, on one specimen ($R=18.5$ mm.) with the aboral spines of the inferomarginal plates missing. I find them to be wanting in all but the first two or three proximal plates of specimens below $R=20$ mm. It is worth noting that Döderlein describes his specimen of var. *sibogae* as having a pedicellaria in place of a spine on the outer edge of the first inferomarginal plate; that De Loriol saw no pedicellariae in his specimens from Sumatra; that Rudmose Brown mentions none in examples from the Mergui Archipelago; that Koehler found none on the adambulacral plates of specimens from Madras, Burma and the Andamans. Döderlein does not describe pedicellariae in his single specimen of the subspecies of *hartmeyeri*, *siamensis* from the Gulf of Siam. There are no specimens from these regions in the British Museum collection.

There are three small specimens with no more precise locality than "Australia" which have not been described. Bell referred to them (1884, p. 133). $R=10.5, 17$

and 20 mm. None of them has outer spines on the superomarginal plates. The smallest has an inner spine on the first plate only, the second on the first and second, and the largest on the first, second and third. The smallest has no pedicellariae; but the first inferomarginals are without marginal spines so that it may be supposed that pedicellariae would have developed there later. That with $R=17$ mm. has pedicellariae on the actinal intermediate plates and they are incipient on the adambulacral plates. There are pedicellariae on the actinal intermediate, adambulacral and first inferomarginal plates as well as on the paxillar area of the largest specimen.

Conclusions. Though it cannot be said with certainty that *hartmeyeri* and *zebra* are one, it has been shown that the characters used to separate them do not hold good, and are, apart from that, extremely variable. This account is prepared as a contribution to the final solution of the problem.

TABLE OF VARIATIONS

Specimens	R : r in mm.	No. of superomarginal plates	Spines on outer edges of superomarginal plates	Occurrence of PEDICELLARIAE				
				Ventrolateral plates	Adambulacral plates	First inferomarginal plates	Paxillar area	Superomarginal plates
A (part)	11 : 4	12	None	×	—	—	—	—
D (part)	11 : 4	13	None	×	—	—	—	—
J (part)	12 : 4	13	None	×	—	×	—	—
G {	15 : 5	15	None	×	×	Spines	—	—
	15 : 5	15	From 4th or 5th to 7th, 8th or 9th plates	×	—	Spines	—	—
F (part)	19 : 5	16	Extend to 12th plate	—	—	Spines	—	—
D (part)	20 : 5	21	None	×	×	—	—	—
E {	21 : 6.5	17	On nearly all plates	×	×	Spines	×	—
	22 : 7	18	On nearly all plates	×	×	Spines	×	—
A (part)	22 : 7	20	None	×	×	×	×	—
D (part)	23 : 6	25	None	×	×	×	—	—
F (part)	25 : 7	19	Extend to 17th plate	—	—	Spines	—	—
B (part)	25 : 6	23	None	×	×	×	—	—
B (part)	26 : 7	22	None	×	×	×	—	—
F (part)	26 : 7	20	Extend to 16th plate	—	—	Spines	—	—
A (part)	28 : 7.5	22	None	×	×	×	—	—
H (part)	29 : 7.5	25	None	×	—	—	×	—
C	28 : 7.5	22	None	×	×	×	—	—
A (part)	30.5 : 7.5	24	None	×	×	×	—	—
B (part)	31 : 8.5	24	None	×	—	×	—	—
H (part)	32 : 9	23	Extend to 11th plate	×	×	—	—	—
J (part)	46 : 10.5	31	Extend to 18th plate	×	×	×	×	×
K	64 : 11	38	Few on 9th to 14th plates	×	×	×	×	—
D ₁	107 : 14	55	On 14th and 15th plates on one side of one arm	×	×	×	×	×

× denotes "present."

Astropecten brevispinus Sladen

(Plate I, figs. 3 and 4.)

Astropecten brevispinus Sladen, 1883, *J. Linn. Soc. (Zool.)*, 17 : 249 ; 1889 : 198, pl. 33, figs. 1 and 2 pl. 37, figs. 1-3 ; Goto, 1914 : 221 ; Döderlein, 1917 : 60.

Sladen's description of *A. brevispinus* is excellent and complete except that he described only the spinelets of the actinal intermediate plates and not the plates themselves. They are of exceptional interest.

In the adult specimen ($R=32$ mm.) there are four chevrons in each inter-radius. In the first there are nineteen plates on either side reaching to the twelfth inferomarginal, which is about three-quarters of the way down the arm. In the second and third chevrons there are on either side seven and four plates reaching, respectively, the fourth and second inferomarginal. The fourth chevron is of six plates, three on either side ; they are in contact with the first inferomarginal. The larger actinal intermediate plates in the interradian area are strongly arched in the middle.

In the "young phase" ($R=16.5$ mm.) there are three chevrons having respectively six, three and single plates on either side. The first row reaches the third inferomarginal ; the second and third are in contact with the first inferomarginal.

The possession of these plates, running far down the arm in the adult, might cause the species to fall nearer *Persephonaster* than *Astropecten* in Fisher's key (1911, p. 39). But Goto (1914, p. 221) could not be certain of their presence, and did not explicitly surmise it, when he placed the species in *Persephonaster*.¹ He did so because of the close relations he saw between it and his *Persephonaster triacanthus*. He placed the latter in *Persephonaster* despite its "very strong external resemblance to *Astropecten*" because, above all, it possessed an anus. "The only single character of decisive value that distinguishes the genus (*Persephonaster*) from *Astropecten* is the presence of the anus," he wrote (p. 221). On the other hand, Fisher (1911, p. 38) says of the anus that "No more unstable character can be conjured up to separate *Astropecten* and its near relatives from *Plutonaster*, *Dytaster*, or *Dipsacaster* . . . there is good evidence that the character is variable within a genus (*Astropecten*, etc., etc.)." I cannot see an anus in *Astropecten brevispinus*.

There is no doubt that Sladen's *Astropecten brevispinus* and Goto's *Persephonaster triacanthus* are very closely related. Their general facies is undoubtedly more *Astropecten* than *Persephonaster* and so are the nature of the adambulacral and mouth-plate armature, and of the paxillae. It therefore seems better to call them so.

Astropecten mesactus Sladen

(Plate I, figs. 5 and 6.)

Astropecten mesactus Sladen, 1883, *J. Linn. Soc. (Zool.)*, 18 : 267 ; 1889 : 219, pl. 34, figs. 5 and 6 ; pl. 38, figs. 7-9 ; Döderlein, 1917 : 59.
non Studer, 1884, *Abh. preuss. Akad. Wiss.* : 46.

Sladen described this as a "very abnormal *Astropecten*" which he admitted "not without hesitation" into the genus. "The character of the abactinal paxillae (the pedicel being represented only by a broad tubercular eminence of the plate) and the great development of the actinal interradian areas are altogether unlike any *Astropecten* with which I am acquainted" (1889, p. 221). Sladen's description

¹ Döderlein (1921, p. 26) gives a list of the species of *Persephonaster* known at that time. He omits the three species described by Goto (1914).

of it is of his usual excellence except that he does not fully describe the actinal intermediate plates. They extend two-thirds of the way down the arms.

There are four clearly marked chevrons. The first has twenty-two plates in each limb, reaching the twelfth inferomarginal. The second, with nine plates (including a single plate at the apex), and the third with four plates on each side, reach respectively the fourth and second inferomarginals. The fourth chevron is of four plates, two in each limb, the outer touching the first inferomarginals.

There appear to be no other references to this species than those given above.

Astropecten pectinatus Sladen

(Plate II, fig. 5.)

Astropecten pectinatus Sladen, 1883, *J. Linn. Soc. (Zool.)*, 17 : 251 ; 1889 : 202, pl. 33, figs. 3 and 4 ; pl. 37, figs. 4-6.

Description. There are ten specimens in the Museum collection. Eight are "Challenger" specimens as follows : Port Jackson, five ; St. 161, off entrance to Port Philip, two ; St. 162, Bass Strait, one. The other two, dried specimens in good condition, were collected by J. B. Wilson, Esq., at Port Philip Heads in or before 1885.

I find Sladen to have been wrong in his description of the actinal intermediate plates, which is as follows : "The actinal intermediate plates, which are small and very few in number, are confined to the immediate interradiar area. The spinelets that cover them are small, more or less subspatulate in form, and radiate apart."

One of the smallest specimens (Port Jackson, $R=28$ mm., $r=8$ mm., with eighteen superomarginals) has two rows of actinal intermediate plates on either side. The first extends far down the arm to the seventh inferomarginal and consists of thirteen plates. The most distal are very small and cannot be seen until the spines of the adjacent inferomarginals and adambulacrals are removed. The second row is of three plates (including the unpaired plate at the apex of the chevron formed by the two rows in one interradius). The actinal intermediate plates carry tufts of spinelets. Those of the inner row are of smaller spines and fewer in number (seven to eight) on the innermost plates than on those farther out in the interradiar area. The plates of the second row have a greatly enlarged and flattened central spinelet ; it is as big as those on the aboral edge of the first inferomarginal plates.

In the smaller specimen from Port Philip Heads ($R=35$ mm., $r=10.5$ mm., nineteen superomarginals) there are three rows of actinal intermediate plates on either side. The first is of twenty-three plates and extends to the thirteenth inferomarginal. The second is of four plates. The third "row," if it may be so called, is represented by one minute plate. The plates of the second row and some of those of the first row in the interradiar area (not down the arms) have the greatly enlarged spinelet described in the specimen above ; on some plates it is double.

There are similarly three rows of plates in the specimen upon which Sladen based his description ($R=48$ mm., $r=14$ mm., twenty-one superomarginals). But the first is of only sixteen plates, reaching the ninth inferomarginal. The second and third rows are of four and single plates respectively.

The largest specimen in the collection is the second from Port Philip Heads ($R=56$ mm., $r=16$ mm., twenty-one superomarginals). It has four rows of actinal intermediate plates on either side. There are no less than twenty-seven

plates in the inner row, reaching the fourteenth inferomarginal plate. The second row is of eight plates and it too extends into the arm, as far as the fourth inferomarginal. The third and fourth rows are of three and two plates respectively, those of the latter being very small. The plates of the second and third rows of this specimen, and those of the second row of the preceding specimen, have an enlarged blade-like spine like that described for the smaller specimens above.

The figures in the above descriptions are shown in the following table :—

Specimen	No. of rows of actinal intermediate plates	First row		Second row	Third row	Fourth row
		No. of plates	Reaching infero-marginal	No. of plates	No. of plates	No. of plates
R 28	2	13	7	3	—	—
R 35	3	23	13	4	1	—
R 48	3	16	9	4	1	—
R 56	4	27	14	8	3	2

Discussion. *Astropecten pectinatus* has been shown to have a large number of actinal intermediate plates ; and the number of plates and of rows increases with size. It is clear that had Döderlein known this he would have assigned the single specimen from Tasmania upon which he based his species *schayeri* to *pectinatus* ; for (1917, p. 62) he wrote : "Ich würde beide Formen zu einer Art vereinigen, wenn nicht Sladen ausdrücklich angegeben hätte, dass *A. pectinatus* nur sehr wenige Ventrolateralplatten besitzt."

For all that, I do not find it easy to declare *schayeri* a synonym of *pectinatus* ; for Döderlein describes the adambulacral armature of the former as being so different from that of the latter (which is essentially as Sladen described it) ; and Clark (1938, p. 66) emphasises the description. I think, after a careful comparison of my largest specimen of *A. pectinatus* and Döderlein's fig. 1, pl. 7 of *A. schayeri*, of nearly the same size, that Döderlein in describing the spines on the ventral surface of the adambulacral plate as up to seventeen in number may have taken the spines of the adjacent actinal intermediate plate into his count. They would not be equal in size—nor do they appear so in his photograph. This is assuming that there are more plates in the first row than he describes ; which I think is possible, for the distal plates in *A. pectinatus* are small and hard to see unless all neighbouring spines are removed.

I cannot agree with Clark (*loc. cit.*) when he says that "the difference in the large spines of the inferomarginal plates (of *pectinatus* and *schayeri*) is very great." I find them to be quite similar. The inferomarginal armature of *A. syntomus* (H. L. Clark, 1928, p. 372), with its double fringe of spines, is clearly different, but the species must be closely related to *pectinatus*. It is worth adding that its actinal intermediate plates are similarly armed ; as are those of Döderlein's *A. schayeri*.

The occurrence of spines on the superomarginal plates is, on the whole, regular. But on one arm of one specimen (R=32 mm.) the third to seventh plates are unarmed ; in another (R=48 mm.) many plates are unarmed, especially in mid-arm ; in others an odd plate here and there has no spine. In the largest specimen (R=56 mm.) some of the plates in the arm angle have two spines.

Astropecten sphenoplax Bell

(Plate II, figs. 1-3.)

Astropecten sphenoplax Bell, 1892a, *Sci. Proc. R. Dublin Soc.*, 7: 522, pl. 22; 1892b: 68, pl. 9; Koehler, 1909: 42, pl. 17, fig. 8; Mortensen, 1927: 59.

Bell records seven specimens. I find six in the collection, one of which is dry. Bell gave measurements of only three and did not include the largest among them. The following are my measurements of these:—

R	r	No. of superomarginals	Remarks
ca. 72	ca. 15	29	Distorted.
ca. 70	14	30	Distorted.
58	14	30	
56	12	28	
52	12	24	Dry.
ca. 41	9.5	ca. 21	Arm tips missing.

The paxillae have not been described. They are small and crowded near the centre of the disk and at the ends of the arms. On the proximal parts of the arms they are arranged in transverse rows on either side, but are irregularly disposed in the centre. In the distal part of the arm the arrangement is irregular throughout. The larger paxillae bear forty to fifty fine spinelets with no difference between those which are peripheral and those in the centre. In one specimen only (the dry specimen) one central spinelet of a small proportion of the paxillae on the outer part of the disk and in the proximal half of the arm is enlarged to many times the size of its fellows. When shorn of their spinelets the pedicels of the paxillae are seen to be low and rounded, not hour-glass shaped.

The superomarginal plates do not meet near the tips of the arm as Bell states, though they come very near to doing so. Koehler described his two specimens as having a spine, or the scar of a spine, on each superomarginal. It is not so in these specimens: spines are of irregular occurrence and vary from one individual to another. They are most frequently absent from the arm angles and if present there are very small. Where they occur they are largest, up to 2 mm. long, in the region of the fourth to tenth superomarginals and thereafter become smaller. They are most frequently missing on the outer parts of the arms. In the largest specimen they are present only on the fourth and fifth plates of some arms, and are represented by tubercles on a few of the succeeding plates.

Apart from their larger spines the marginals are densely covered with very fine spinelets which stand out at right angles to the plates and are not flattened or scale-like.

The actinal intermediate plates are more numerous and extend farther into the arms than previous descriptions have shown. Those of three specimens have been examined. In the smallest (R=ca. 41 mm.) there are three rows, the first of ten plates extending to the fifth inferomarginal; the second, third and fourth of five, three and single plates respectively. The dry specimen (R=52 mm.) has twelve plates in the first row reaching the seventh inferomarginal; the second row has five plates, and the third has four plates on one side, five on the other. Five plates irregularly arranged in the angle of the chevron formed by the third rows represent the fourth rows.

It is curious that in the largest specimen ($R = ca. 72$ mm.) there are only three rows. The first is of fifteen plates reaching the seventh inferomarginal, the second of five, the third of two plates.

Expressed in another way, the actinal intermediate plates reach, in the three specimens examined, between a third and half-way down the arms.

***Astropecten triseriatus* Müller and Troschel**

Astropecten triseriatus Müller and Troschel, 1843, *Arch. Naturgesch.*, **9** (1) : 118 ; Döderlein, 1917 : 125, pl. 5, figs. 2-3 ; pl. 11, figs. 5, 6-6a ; Clark, H. L., 1938 : 66.
Astropecten arenarius Perrier, 1876, *Arch. Zool. exp. gén.*, **5** : 286.
Astropecten triseriatus myobrachioides Fisher, 1925, *Bull. Bishop Mus., Honolulu*, **27** : 69, pl. 5, fig. B.

The only specimens of this species previously described are as follows :—

From south Western Australia: the type (Müller and Troschel and Döderlein) ; part of one arm (H. L. Clark).

From north Western Australia : one specimen (Döderlein).

From an unknown locality : one specimen (Perrier).

From the Hawaiian Islands : one specimen of the subspecies *myobrachioides* (Fisher).

It is therefore worth while to give some details of the two specimens in the British Museum collection, as well as a full account of a third which is described as a new subspecies. The measurements of all the known specimens, including those of the new subspecies, are brought together in the table (p. 501).

Specimen from Bass Strait, $R=54$ mm., $r=12$ mm., thirty-one superomarginals. Only one arm is of normal length ; each of the others was broken and is in part regenerated. None of the paxillae have enlarged central spinelets. There is, as a rule, only one spine on the first four superomarginal plates ; it is slightly longer than one plate, being 2 mm. long. The succeeding plates have two, three or—towards the end of the arm—one spine. Where there are two or three the outermost is the larger, being as long as one plate. The marginal spine of the inferomarginal plates is as long as three plates. There are two inside it as described by Döderlein, but the first of them is more than half as long as the marginal spine. Only the more proximal of the inferomarginal plates have one or two larger spines along the aboral edge. There is only one actinal intermediate plate on either side. The madreporite is 3 mm. long ; a few small scattered spines arise from its surface.

Specimen from an unknown locality, $R=84$ mm., $r=17$ mm., thirty-seven superomarginals. In some arm angles the first pair of superomarginals carry only one spine each ; in others there is a second and smaller outer spine. The remaining plates carry three, sometimes four, spines, of which the lowermost is the longest ; it is nearly as long as two plates in the middle part of the arm, but shorter towards the end. The three large spines of the inferomarginal plates have some of the spinelets at their bases enlarged to spines. The row of aboral spines, three, two or one in number, extends to about the eighteenth plate. There are two actinal intermediate plates on each side. The madreporite is 4 mm. long with a few small scattered spines.

MEASUREMENTS

Specimen	R : r in mm.	No. of supero- marginal plates
Subsp. <i>myobrachi</i>	41 : 12 = 3.4	20
Bass Strait (British Museum) ...	54 : 12 = 4.5	31
Type	65 : 17 = 3.8	30
Subsp. <i>fijiensis</i> (British Museum) ...	66 : 17 = 3.9	25
Perrier	82 : 18 = 4.6	35
Unknown locality (British Museum) ...	84 : 17 = 5	37
Döderlein	95 : 23 = 4.2	35

***Astropecten triseriatus fijiensis* subsp. nov.**

(Plate II, fig. 4.)

This new subspecies is based on a single dry specimen in good condition from the Fiji Islands which came to the Museum in 1862 or earlier. There are no details of depth, etc.

R=66 mm., r= 17 mm. R=3.9 r. Number of superomarginal plates, twenty-five.

This subspecies differs from *A. triseriatus* in the smaller number of superomarginal plates, the great development of the first pair, and the unarmed condition of the second pair, of superomarginal plates.

The larger paxillae have one to six central spinelets which are often of very unequal size, and nine to twelve peripheral spinelets. Many of those on the disk and near the base of the arms have one spinelet, usually but not always the central one, strongly enlarged, or one or two less markedly enlarged. There are about fourteen paxillae across the base of the arm.

The most striking feature of the superomarginal plates is the great size of the first pair: they rise strongly above the level of the remainder, swelling out as they do so, so that their dorsal width is many times their width at the base. And each carries a larger spine, 5 mm. long, than any other plate. With one exception the second superomarginal plates are narrow and unarmed. The third and fourth, or the third, fourth and fifth, plates each carries one large spine about 4 mm. long. The remaining plates have smaller spines. There are usually three, but sometimes two or four. They are irregular in size and may be so in arrangement—*i.e.*, they are not always in a straight line. The largest is about as long as one plate. The spinelets at the base of the spine are enlarged.

The inferomarginal plates are covered with long spinelets with narrow bases which gradually widen to rounded flattened ends. They are small in the furrows between the plates, greatly enlarged around the bases of the spines described below. Each plate carries on the outer margin one strong pointed spine about as long as two plates. A similar but somewhat smaller and more flattened spine stands inside and slightly aboral to it; it is the first of an aboral row of three or four. The remaining two or three are much shorter and are flattened, pointed and blade-like. In the proximal part of the arm there is frequently a second spine standing on the adoral side of the outermost spine of the aboral row; it is about half as long as its neighbour.

The adambulacral armature in the proximal part of the arm consists of three long and equal furrow spines followed by three similar pairs of spines, one behind the other, each a little smaller than the last; the aboral spine of the first pair is as long as the furrow spines, the adoral is slightly smaller. Farther out on the arm there are only two pairs of spines behind the furrow series.

The combined mouth plates bear a pair of large spines at the inner angle ; each is followed by five smaller spines along the furrow margin. The strongly raised central portion is lenticular in shape and carries nine or ten spines on either side, the space between them being free of spines, except on one plate where one occurs.

There are two actinal intermediate plates on either side, each with a group of nine to twelve long spines similar to those on the inferomarginal plates.

The madreporite is 3 mm. long and bears a group of low spines.

***Astropecten michaelsoni* Koehler.**

Astropecten michaelsoni Koehler, 1914, *Beitr. Meeresfauna Westafri.*, 2 : 144, pl. 4, figs. 3-6, 8-11 ; pl. 5, figs. 1, 2, 13, 16-17.
Astropecten dahomensis Döderlein, 1917, *Siboga Exped. Monog.* 46a : 77, pl. 16, figs. 3-3d ; text-fig. Q.

There can be no doubt that Koehler's and Döderlein's species are the same. I can find no reference to either of them since the original descriptions. There are twelve specimens in the Museum collection, eleven of which were collected in recent years on the Gold Coast by Dr. F. R. Irvine and Miss V. J. Foote of Achimoto College, Accra. The twelfth came in 1890 and is from Gambia and so extends the previously known range, which was from 7 deg. S. to 9 deg. N.

There is little to add to Koehler's excellent description based on nearly fifty specimens. Two of the specimens, the one from Gambia and the other from the Gold Coast, are bigger than the remainder, having each $R=63$ mm. In neither are the central granules on the paxillae enlarged as in all the other, smaller, specimens. But they differ in the arming of the superomarginal plates. In the Gambia specimens there are no spines. On the ninth and succeeding plates an enlarged granule, circular in outline, occupies the position normal for the external spine. It rises hardly at all above the level of its smaller fellows until it reaches the end of the arm. The Gold Coast specimen of the same size has strong spines; on many plates, including some in the arm angle, there are three.

A specimen of $R=56$ mm. shows nine to ten actinal intermediate plates, reaching to the sixth inferomarginal, on either side.

A note attached to a large specimen from Labadi describes it as having been salmon red in life, and the species as being common along the coast. Some, if not all, of the specimens come from rock pools. A batch of five taken at Elmina are, in spirit, a very dark brown with tube-feet deep purple.

***Astropecten antillensis* Lütken.**

Astropecten antillensis Lütken, 1859, *Vidensk. Medd. naturh. Foren. Kbh.* 1 : 47 ; Döderlein, 1917 : 105, pl. 2, figs. 9-10 ; pl. 9, figs. 7 and 8 ; Clark, 1933 : 16 ; Boone, 1933 : 75, pls. 31-32.

Sladen in the Challenger Report (p. 198) records *A. brasiliensis* from "Off Bahia. Depth 7 to 20 fms." The jar so labelled in the Museum collection contained nine specimens, of which four were *brasiliensis*, but the remaining five are undoubtedly *A. antillensis* Lütken. Another jar contains two specimens of *antillensis* labelled "from ? Bahia" which were presented in 1903 by the Earl of Crawford. The species does not previously appear to have been recorded from anywhere but the West Indies.

Another specimen ($R=35$ mm.), which came to the Museum in 1848 from "S. America," is a typical *A. antillensis* except that there is a band of paxillae, encircling the area of small paxillae on the centre of the disk, in which each has a single central spinelet which is considerably enlarged.

***Astropecten brasiliensis armatus* Gray**

(Plate III, figs. 1 and 2.)

Astropecten armatus Gray, 1840, *Ann. Mag. Nat. Hist.*, 6 : 181 ; Fisher, 1911 : 56, pl. 5, figs. 1 and 2 ; pl. 7, figs. 3 and 6 ; pl. 50, fig. 4 ; pl. 51, fig. 3.

Astropecten brasiliensis armatus Döderlein, 1917, *Siboga Exped. Monog.* 46a : 84 ; with earlier references and synonymy : 170.

Description of Type Specimen. $R=65$ mm., $r=14$ mm., $R:r=4.6$. The larger paxillae have seven to nine central and twelve to fifteen peripheral spinelets. The central spinelets are globose and unequal in size, the larger being slightly bigger than those of the periphery, which are equal. None of the central spinelets are fused together.

There are twenty-three superomarginal plates which are large and high, particularly in the arm angle. The first bears a spine over 4 mm. long on its inner edge. With some exceptions the second and third plates each bear a much smaller spine on or near the inner edge. A series of strong outer spines begins on the second or third plate and extends to, or to within one or two plates of, the end of the ray. On a number of the second and third plates there are therefore two spines ; the outer is stronger than the inner. Double spines occur irregularly and infrequently farther out on the ray. The general surface is covered with upstanding spinelets which are largest, as big as those of the paxillae, on the abactinal surface ; they become smaller near the lower margin and fine and capillary towards the fasciolar grooves.

The inferomarginals project appreciably beyond the superomarginals. They are thickly covered with short flattened spinelets with truncated ends. They are finer and very numerous on the adambulacral margin and slender and capillary on the edges of the fasciolar grooves. There are two large spines on the outer margin, the larger above and slightly adoral to the smaller. The larger may be as long as three plates, the smaller slightly over half as long. These spines are not, or are only slightly, flattened. Smaller spines arise around their bases and a row of two or three spines, about as long as one plate, arises from the aboral margin of the plate. There is no corresponding adoral row, but there is frequently a single spine near the adoral edge and the adambulacral plates.

There are three furrow spines, of which the middle is the strongest and longest. Their ends are faintly scooped in that each has a short longitudinal groove on the under side. In the second row there is one enormous blade-like spine nearly 3 mm. long and, adorally to it, a spine less than half its length which is slender. The end of the large spine is, in the proximal part of the ray, enlarged as shown in Fisher's pl. 7, fig. 3, but not so strongly as in his pl. 51, fig. 3. It is very faintly scooped at the end. In the "third row" there are three to five slender spines about equal to the adoral member of the second row. They may be in a group or a row.

The preservation of the mouth-plates does not permit of an accurate description of the armature ; what can be seen of it appears to agree with Fisher's description.

There are four actinal intermediate plates on either side. They carry groups of slender spinelets, but do not have the larger spines described in some specimens by Fisher.

The madreporite is about 4 mm. in diameter and is separated by one row of paxillae from the superomarginals. Very small spines arise from the ridges of its striations.

Discussion. Gray describes under *armatus* a variety *pulcher*. The locality he gives may, both in the 1840 paper and in his Synopsis (1866), be read as applying only to the variety, and Döderlein (1917, pp. 169 and 170) has so read it. On the other hand, since it is his custom elsewhere throughout the 1840 paper and the Synopsis to give localities or to indicate where they are not known that it is so, the locality of Puerto Portrero may be read as applying both to *armatus* and its variety. It appears to me that Fisher (1911, p. 60) has done this. I also do so; and I think I am right because of evidence afforded by the specimen described above. It is accompanied by a very old label reading "Puerto Portrero, C.A., sandy bottom, 9 fms."; it has inferomarginals which are produced beyond the superomarginals; it has a second label in the writing of E. A. Smith (who was in charge of the collection from 1867 to 1878) which reads "*Astropecten armatus* Gray (type)" and the initials "E. A. S." Because the variety *pulcher* had "the under series of marginal tubercles not produced," and because Smith stood much nearer to the event than I stand, I believe this to be the type of *armatus*; and, because it has a label saying so, that it came from Puerto Portrero. No trace of the variety *pulcher* has been found.

A further discussion of this subspecies appears below after the description of *A. brasiliensis erinaceus*.

***Astropecten brasiliensis erinaceus* Gray**

(Plate IV, figs. 1 and 2.)

Astropecten erinaceus Gray, 1840, *Ann. Mag. Nat. Hist.* 6 : 182; Boone, 1928 : 3, pl. 2.

Astropecten brasiliensis erinaceus Döderlein, 1917, *Siboga Exped. Monog.* 46a : 84; with earlier references and synonymy : 169, pl. 8, figs. 4-4a.

Description of Type Specimen. R=65 mm., r=14 mm., R : r=4.6

The paxillae are similar to those of *armatus*.

The superomarginal plates number twenty-three. They are similar to those of *armatus* except that the inner row of spines, present in *armatus* on the first to third plates only, extends as far down the ray as to the thirteenth or fifteenth plate. It is often absent from the fifth plate, which carries a large spine of the outer row. The latter starts on the fourth plate and continues to the end, or to near the end, of the ray. Most plates therefore have two spines; the outer is conspicuously stronger than the inner. The single spines on the first plates are the strongest of all, being nearly 4 mm. long. On a few plates the single inner spine is replaced by two.

The general covering and armature of the inferomarginals is similar to that of *armatus*. The outermost of the spines along the aboral edge is enlarged so as to appear, with the two marginal spines with which it stands in line, as one of a series of three.

The arrangement and proportions of the adambulacral spines are the same as in *armatus* except that the big spine of the second row is not so big. In the proximal part of the ray where it is 2.5 mm. long its end is only very faintly, if at all, expanded. In the distal part of the ray it is not expanded at all; the free end is narrower than the base. The ends of this large spine and of the furrow spines are strongly grooved on the under, the outer, side.

There are only two, exceptionally three, actinal intermediate plates on either side. They are armed with groups of slender spinelets like those on the adambulacral edges of the adjacent inferomarginals. On some of them one of the spines is larger than the remainder and compressed.

The mouth-plates and madreporite are as in *armatus*.

Discussion. Earlier writers had written of *erinaceus* as identical with *armatus* (see Fisher, 1911, p. 60), but Döderlein nevertheless regarded them as distinct and treated each as a subspecies of *brasiliensis*. Two recent authors have not followed Döderlein though neither has given reasons for not doing so: Boone (1928, p. 3) writes of *erinaceus* as a separate species, and Clark (1940, p. 322) of *armatus* as a species in Fisher's sense (including *erinaceus*).

There are not in the British Museum collection any other specimens of *armatus* or *erinaceus* than the specimens described above; so that my only possible contribution to the problem of whether or not they are distinct is that of describing those specimens. If they are distinct, these are the types.

Döderlein describes the differences between *armatus* and *erinaceus* as being in the number and arrangement of the superomarginal spines, and in the nature of the enlarged adambulacral spine. Superomarginal spines may be so very variable in so many species that I think they may be discounted in this discussion. The differences which Döderlein describes between the large adambulacral spine are shown, for what they may be worth, by the types described above.

Döderlein's picture of the under surface of the inferomarginals of *erinaceus* (pl. 8, fig. 4a) shows no isolated spine near the adoral and adambulacral edge. Such a spine occurs in the types of both *erinaceus* and *armatus*. It is not present in Fisher's picture of the inferomarginals of *armatus* (1911, pl. 7, fig. 3).

Astropecten mauritianus Gray

(Plate IV, figs. 3 and 4.)

Astropecten mauritianus Gray, 1840, *Ann. Mag. Nat. Hist.* **6**: 182; 1866, 3; Perrier, 1876: 346 and 359; Döderlein, 1917: 127; non Koehler, 1910: 32.; ? non Brown, 1910: 29.

Astropecten mauritianus var. *mascarena* Döderlein, 1917, *Siboga Exped. Monog.* **48a**: 143, pl. 6, fig. 3; pl. 13, figs. 2-2b.

Astropecten hemprichii, Loriol, 1885, *Mém. Soc. Phys. Genève*, **29** (4): 74, pl. 21, figs. 7 and 8.

Astropecten sp. Loriol, 1885, *Mém. Soc. Phys. Genève*, **29** (4): 77, pl. 22, fig. 1.

Description of Type Specimen. R=57 mm., r=18.5 mm., R:r=3:1. Locality: Mauritius.

The specimen is very brittle. Two of the rays are broken off and parts of the paxillar fields of those which remain have fallen in.

Most of the larger paxillae have eight or nine central, and fifteen or sixteen peripheral, spinelets, with the central slightly larger than the peripheral. The central spinelets may be more numerous, up to sixteen, and no bigger than the peripheral. The paxillae are very small in the centre of the disk and at the ends of the rays. In the proximal part of the ray those in the centre are larger than those, which are regularly arranged, on the sides.

There are twenty-one superomarginal plates. They encroach strongly on the abactinal surface particularly in the proximal part of the ray, where they have a more rounded contour than in the distal part. They are covered with low rounded granules which are of the same diameter as, but lower than, the largest of the paxillar spinelets. On each plate there are about six irregular rows of granules, those near the margin smaller than those in the centre. The fasciolar grooves are fringed by fine capillary spinelets. Each plate, except for the first two or three, bears a small conical spine on the outer edge. On the proximal plates it is small, less than half as long as a plate; it is larger, but never as long as a plate, in the distal part of the ray.

The inferomarginals do not project as far as the superomarginals in the arm-angles, but do so slightly beyond them in the distal part of the ray. They are covered, though not thickly, with narrow flattened spinelets with rounded ends. Large flattened spines arise from among them. The most conspicuous form a row of three or four along the aboral edge; there is a less conspicuous row of shorter spines along the adoral edge, and one or two arise from the middle of the plate. On the outer margin there is one long spine nearly as long as three plates. Its base is rounded, but it is compressed towards the end which is sharply pointed. Three flattened spines stand in a row parallel to the axis of the ray below the marginal spine. The aboral is the longest, being half as long as the marginal spine. The spinelets of the fasciolar groove are capillary.

There are three furrow spines of which the middle is the longest. It is not much stouter than the other two and is only slightly compressed. There are two, or exceptionally three, spines in the second row. The aboral is nearly as long as the furrow spine; it is longer and stouter than the adoral. A row or a group of three to five much smaller spines comprise the third row.

The mouthplates are prominent. Parallel to the suture there is on either side a row of about ten roughly equal spines, ending in a very large spine at the inner end. The free margin on either side appears to have about seven spines which grow in size from the outer to the inner end. The innermost stands beside the largest of the first series and is only slightly smaller than it.

There are three actinal intermediate plates on either side. They are armed with groups of spines somewhat similar in size to those of the third row of the adambulacral plates.

The madreporite is small. A number of low irregular mound-like granules are borne on its surface.

Description of Second Specimen. There is a second and larger specimen in the Museum collection: $R=82$ mm., $r=22$ mm., $R:r=3.7$; twenty-seven superomarginal plates. It is labelled "Isle of France" (Mauritius). There are no other data with it, but it is probably old for it is broken and brittle. It differs from the type in a number of small ways.

The central spinelets of the paxillae are globose and markedly larger than the peripheral. They are often arranged in a circle around one which is central. The larger paxillae tend to be polygonal. This heightens the contrast between the irregularly arranged paxillae down the centre of the rays and the smaller ones which are regularly disposed on either side of them.

On one of the arms the superomarginal spines begin on the fourth plate, on the other four on the fifth. In each of the five arm-angles one of the first superomarginal plates, but not the other, has a single enlarged granule like an incipient spine.

On the inferomarginals there is a higher proportion of spines to spinelets than in the type; there are ten to twelve to each plate apart from the three below the large marginal spine.

On the adambulacral plates one of the spines in the groups which comprise the third row is often enlarged. Similarly on the actinal intermediate plates one or two spines are considerably bigger than the others. The madreporite is almost completely hidden.

Discussion. Perrier records that he studied Gray's types of this species at the British Museum. He describes them as having strong conical spines on the

inner margins of the first and neighbouring superomarginal plates. It was an error, difficult to understand and unfortunate in its effects, for it has been copied by Lorient, Koehler, Brown and Döderlein. The latter would not have created his variety *mascarena* were it not for this error: there is no doubt that the specimens described under that name are *mauritanus*.

Brown states that he named his specimen from the Mergui Archipelago after careful comparison with the specimens in the British Museum. It cannot have been with the only two specimens of *mauritanus* or he could not have failed to detect Perrier's mistake. It must remain doubtful what species he was describing until his specimens can be re-examined.

Astropecten mauritanus is known only from Mauritius.

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